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Lactarius fumosibrunneus in a relict *Fagus grandifolia* var. *mexicana* population in a Mexican montane cloud forest

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Abstract — *Lactarius fumosibrunneus*, a species considered in the literature contaxic with *L. fumosus,* is interpreted here as an independent taxon due to the differences in the structure of pileipellis and presence of cystidia. Recognition of *L. fumosibrunneus* is supported by morphological comparison with original collections, Mexican samples, and type specimens of related taxa. Collections of *L. fumosibrunneus* were found in the Mexican montane cloud forest of Central Veracruz (east coast of Mexico) where it appears to be ectomycorrhizal partner of the tree *Fagus grandifolia* var. *mexicana*.

Key words — ectomycorrhizal fungi, *Fagaceae*, neotropical fungi, *Russulaceae,* taxonomy

Introduction

Lactarius fumosibrunneus A.H. Sm. & Hesler is an American member of subgenus *Plinthogalus* (Burl.) Hesler & A.H. Sm. described by Smith & Hesler (1962) from Michigan, U.S.A. Based on the macroscopical resemblance of *L. fumosibrunneus* with *L. fumosus* Peck, Hesler & Smith (1979) considered it as conspecific. During a regular monitoring of the Mexican montane cloud forest in Veracruz (east coast of Mexico) by the authors (Montoya et al. 2010), some populations of a taxon macroscopically close to the aforementioned species were observed. After a comparative study of collections of these populations with specimens from U.S.A. (including type materials) of *L. fumosibrunneus, L. fumosus,* and *L. fumosoides* A.H. Sm. & Hesler, we found that based on differences in the nature of the pileipellis and cheilocystidia, *L. fumosibrunneus* appears distinct from other allied taxa. We therefore consider *L. fumosibrunneus* to represent an independent taxon and support the original concept as published by Smith & Hesler (1962).

Materials & methods

Monitoring was conducted between September 2006–09 in Acatlán Volcano, Central Veracruz (east coast of Mexico). Samples of *Lactarius* were gathered during random field trips in a stand of *Fagus grandifolia* var. *mexicana*. Collections are kept in XAL herbarium. Basidiomes were studied in fresh condition. Colors were compared with those from Kornerup & Wanscher (1967), e.g. codified as 5D5–E5, and Munsell color chart (1994), e.g. 10YR 4/3–4/4. For the study of micromorphological features, hand sections of dried specimens were rehydrated in 3% KOH. Basidiospores (measurement, shape and ornamentation pattern) were observed in Melzer´s reagent. Methods to determine spore ranges are those used by Montoya & Bandala (2003). In the basidiospore descriptions, ***X***m indicates the range of means of basidiospore length and width and Qm indicates the range of the means of Q (length/width ratio) from n collections (25–50 basidiospores were measured per collection then ***X*** indicates their mean). Line drawings were made with the aid of a drawing tube. Acronyms for herbaria follow Holmgren & Holmgren (1998).

Taxonomy

Lactarius fumosibrunneus A.H. Sm. & Hesler, Brittonia 14: 439, 1962 Figs 1–4a

Specimens examined. **MEXICO. Veracruz: Acatlán,** Acatlán Volcano, 14 Sep 2006, Montoya 4625, Montoya 4631, 4633, 4634, 4635; 18 Sep 2007, Montoya 4669; 19 June 2008, Montoya 4680; 30 July 2009, Montoya 4739, Montoya 4740, Montoya 4745 (all at XAL).

Pileus 12–65 mm diam., convex, becoming plane to plano-convex, depressed in the center with age, at times subumbonate, with or without a central papilla, faintly velutinous, dull, smooth when young to rugose at center when mature or at times venose-rugose and faintly rugose in other areas, dry, firm, often pale greyish (10YR 5/4–6/4, 10YR 5/3) or brownish (5D5–E5) or with darker (5E5–E4–E6, 10YR 4/3–4/4) shades but generally conserving paler or even cream colored patches or appearing with greyish-brown tinges over a cream background or more or less uniformly greyish-brown or brownish (around 2.5Y 5/3–4; 6F7, 5B3–C4; pale 5D5–E5, 4B2), darker (7.5YR 4/3, 5E4–E5) towards the center; margin wavy, at times inflexed and irregular, lobulate, edge at times whitish. Lamellae narrow (2–3 mm broad), crowded, short-decurrent to decurrent, cream-colored (2.5Y 8/2–3, 3–4A2) when young to yellowish-ochraceous (5A3, 10 YR 8/3–4, 8/6, 7/6) when old, staining reddish-salmon (8A5–B7) when cut, some furcate, with lamellulae of different length (frequently one longer and two very short), generally 1–3 between two lamellae. Stipe 20–75 × 3–12 mm, subcylindrical, slender, more or less tapering downwards or with tapered base, almost straight, at times weakly sinuous, occasionally curved, firm, hollow

Fig. 1. *Lactarius fumosibrunneus* Montoya 4669. Scale bar= 10 mm.

with age, faintly velutinous, dry, dull, whitish, bone-whitish to cream-colored (2.5 Y 7/3, 8/2, 3A2), later developing pale greyish-brown (5B3–C3–D4, 10YR 5/4–6/4) shades but conserving whitish areas mainly at apex or base; base whitish. Context white to cream-colored, staining pinkish, becoming slowly reddish (9B3, 9C5), finally wine-red to salmon color (7B5–6, 7A5). Odor mild to somewhat similar to chlorine. Taste very hot. KOH negative on pileus and context. Latex white, unchanging, cut surfaces staining reddish, salmon-red (7A6–B6) or even brownish-red (9C8), dried drops stained reddish, staining white paper red (8C5–6), spots on paper slowly turning orange to salmon color (8B5) and to yellow (4A8–A5) with reddish-orange tinges to totally yellow (4A2–3) after some hours.

Basidiospores 7–8(–8.5) × 6.5–7.5(–8) µm, *X*m = 7.4–7.6 × 6.5–7.2 µm, Qm = 1.06–1.07, subglobose, ornamentation 1–2 µm high, subreticulate, composed of broad, sinuous bands forming a somewhat wide mesh, more or less crestate in profile, at times with isolate verrucae, often weakly amyloid in the suprahilar area. Basidia 42–58 × 9–13 µm, clavate, bi- or tetrasporic, sterigma 4–7 µm long. Cheilocystidia 19–50 × 5–7.5 µm, subcylindrical, more or less narrowly lageniform or moderately tapered, apically rounded,

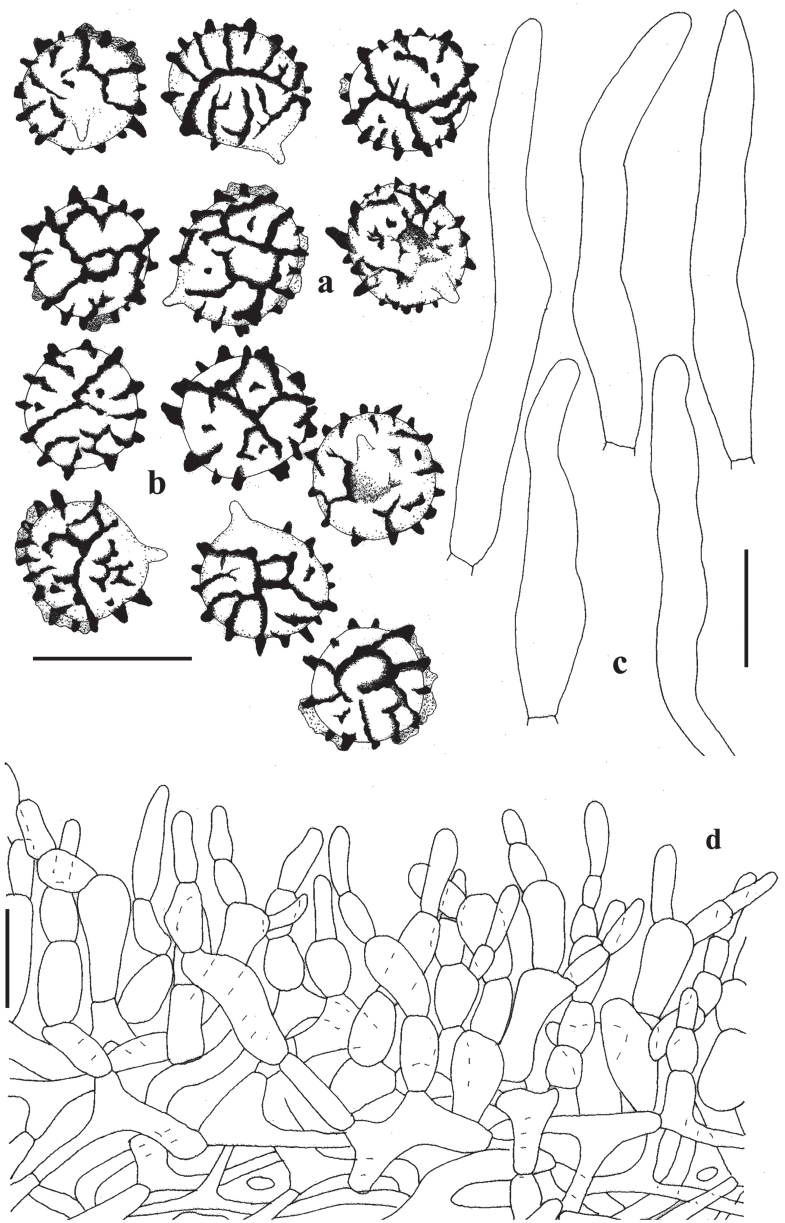

Fig. 2. *Lactarius fumosibrunneus*.
(a–b) basidiospores, (c) cheilocystidia, (d) pileipellis.
[a,c,d= Montoya 4634, b = holotype.] Bars: a–c = 10 μm, d = 20 μm.

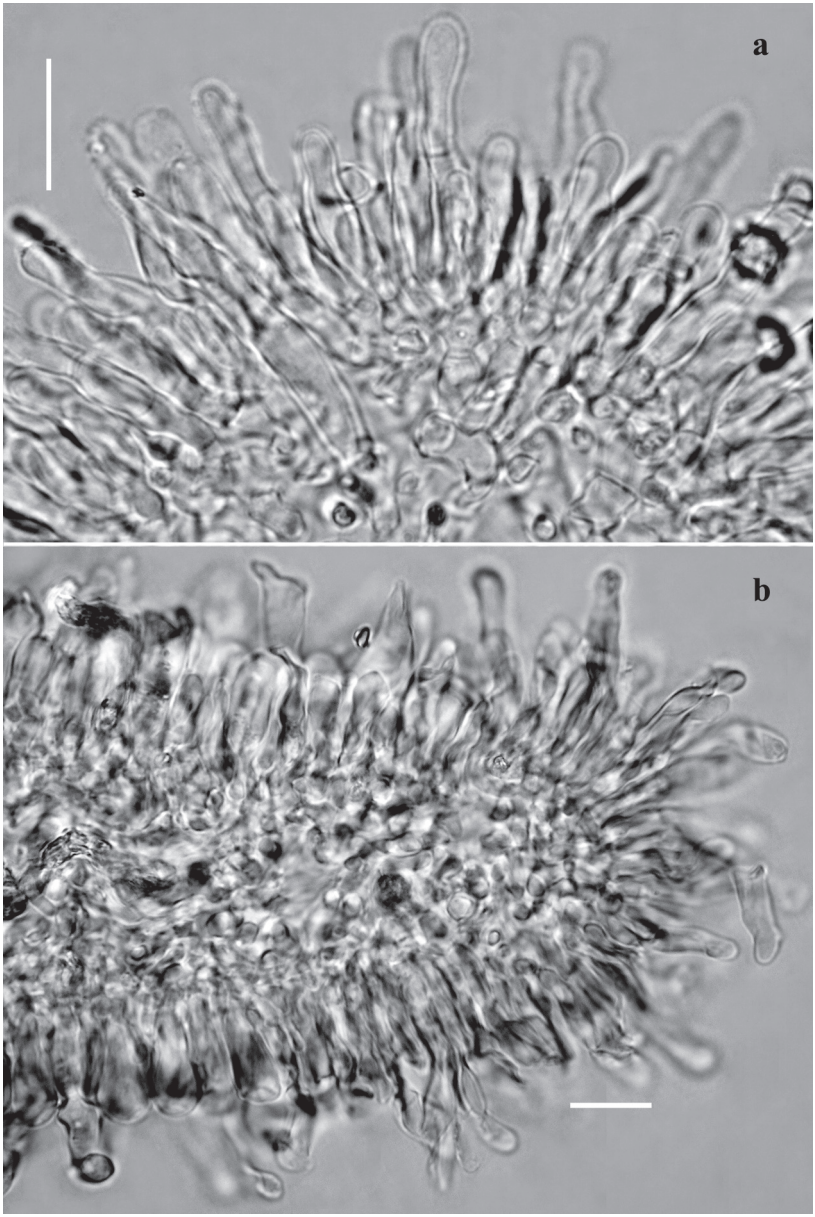

Fig. 3. *Lactarius fumosibrunneus*. Lamellar margin, Montoya 4634. Bars = 20 µm.

sinuous, abundant, emerging above hymenium level, hyaline. Pleurocystidia absent. Pseudocystidia 3–4 µm diam., subcylindrical to vermiform, at times ramified, with refringent colorless contents. Pileipellis a hymenoepithelium, 40–62 µm broad, the elements disposed in anticline chains of 2–4 elements long, cells with pale yellowish–brown contents; terminal cells 11–27 × 5–7 µm, subcylindrical, subventricose, pyriform, sinuous, the remaining cells in the chains versiform, those immediately below the terminal element in general broadly subcylindrical, 8–10 × 5–7 µm, other subisodiametric 9–15 µm diam. or more or less versiform and broad, 10–25 × 8–13 µm diam. Context heteromerous, hyphae 2.5–10.8 µm diam., sphaerocytes 18–39.6 µm diam., laticifers 2.5–11 µm diam. Hymenophoral trama heteromerous, hyphae 3–5 µm diam, laticifers 2.5–6 µm diam., with a lax tissue towards lamellar edge.

Habitat — Gregarious in a *Fagus grandifolia* var. *mexicana* forest at 1840 m.

Other specimens examined. **USA. Michigan: Washtenaw Co.,** Sharon Hollow, 13 Aug 1960, A.H. Smith 62897 (as *L. fumosus*, MICH); Cheboygan Co., Reese´s Bog, 27 Aug 1960, A.H. Smith 63040 (holotype of *L. fumosoides* MICH); Cheboygan Co., Colonial Point, Burt Lake, 11 Aug 1961, A.H. Smith 63892 (holotype of *L. fumosibrunneus*, MICH). New York, Sandlake, Rensselaer Co., July, Peck s.n. (as "*L. fuliginosus* var. *fumosus* Peck", NYS).

Discussion

After comparing Mexican materials with specimens and descriptions of *L. fumosibrunneus*, *L. fumosus,* and *L. fumosoides,* we concluded that although they are apparently phenotypically similar, these three taxa could be differentiated because each possesses a unique set of characters. *Lactarius fumosibrunneus* as observed in the type specimen (Smith 63892) presents abundant cheilocystidia distributed at lamellar edges and even placed towards lateral sides of the lamellar margin (Smith & Hesler 1962: '…abundant and extending a short distance up the sides…'); their size and shape (20–57 × 5–7.5 µm, ventricose, subcylindrical, clavate, sinuous) are also similar to Mexican collections (Figs. 2c, 3a-b). Its basidiospores are 7.3–8 × 6.5–7.5 µm, X = 7.6 × 7 µm, Q = 1.1, subreticulate (Fig. 2b). Although the pileipellis (Fig. 4b) was somewhat difficult to rehydrate in the type, it was possible to observe that, as in our Mexican specimens, it is built of groups of elements in chains, basal cells appearing irregular and subisodiametric and the terminal elements having a hymeniform appearance (Fig. 4a). The taste (described as 'burning acrid' by Smith & Hesler 1962) and narrow and crowded lamellae (also observed in Mexican collections) are distinctive. Smith & Hesler (1962) recorded *L. fumosibrunneus* from a beech–maple forest in Michigan.

According to the description by Peck (1872), *Lactarius fumosus* possesses a pileus that is convex and then expanded, slightly depressed in the center,

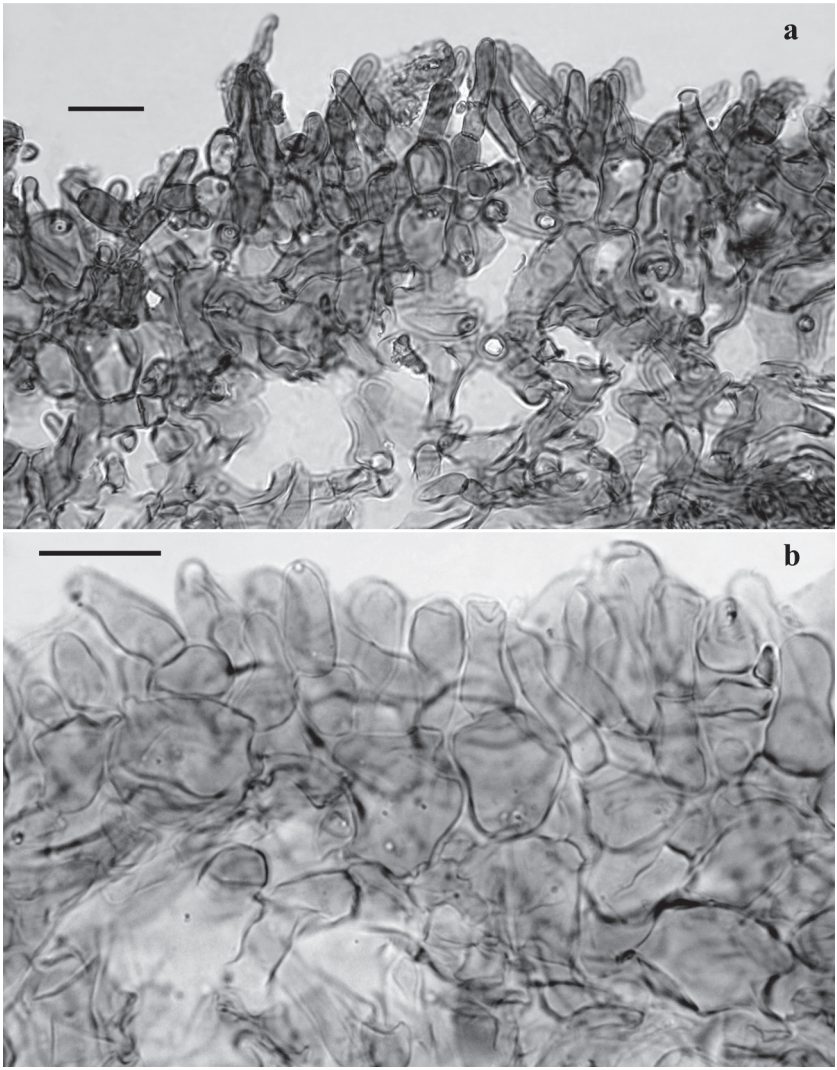

Fig. 4. Pileipellis. Bars = 20 µm.
(a) *Lactarius fumosibrunneus*, Montoya 4634, (b) *L. fumosus*, Smith 62897.

smooth, smoky-brown or sordid white, lamellae close, adnate, flesh white, taste at first mild then acrid. Smith & Hesler (1962) distinguished *L. fumosus* from *L. fumosibrunneus* because basidiomes of the latter are quickly burning-

acrid and have a more highly developed pileipellis structure (also observed for the Mexican collections). Subsequently however, Hesler & Smith (1979) synonymized their *L. fumosibrunneus* with *L. fumosus*, regarding the taste and characteristics of the pileipellis (and stipitipellis) as "… slight quantitative variations…" for recognizing two taxa. They also noted that the cheilocystidia in *L. fumosus* were 'poorly differentiated' [(9–)26–36 × 4.5–6 µm]. It has not been possible to study the type of *L. fumosus*, which according to NYS is apparently lost. For the taxonomic interpretation of *L. fumosus* we examined Peck's specimen (July, NY, Sandlake, Rensselaer Co.; see below) that he identified as *L. fuliginosus* var. *fumosus* and Smith 62897, which Hesler & Smith (1979) considered conspecific with *L. fumosus*. We corroborated in both materials that the lamellar edges lack cheilocystidia and, indeed, bear some basidia and sterile basidiole-like cells (FIGS. 5A-B) (the longest about 10–25 × 3.5–9 µm in the specimen of Peck from Sandlake and 17.5–32.5 × 5–8 µm in the specimen Smith 62897) that could not be considered differentiated cells representing cystidia. The pileipellis (FIG 4B) showed the differences as well, having broader and shorter terminal elements [12–21(–28) × 5–12 µm, broadly clavate, ovoid, subisodiametric and less frequently pyriform]. The basidiospores appear more ellipsoid in both Peck's Sandlake specimen [7–8 (–8.5) × 6.5–7.5(–8) µm, *X* = 7.7 × 6.7 µm, Q = 1.2, n = 25] and Smith 62897 [7–5–8 × 6.5–7.3 µm, *X* = 7.8 × 6.8 µm, Q = 1.15, n = 25].

The type specimen of *Lactarius fumosoides* (treated as *L. fumosus* var. *fumosoides* by Hesler & Smith 1979) was also studied for comparison. This specimen differs from the previous specimens particularly in pileipellis structure and the absence of cheilocystidia. The lamellar edges bear basidiole-like structures and some basidia but no differentiated cystidia. The pileipellis has a lax arrangement, which in some areas appears as a cutis from which some slender pileocystidia [19–68 × 5–7 µm, clavate, subcylindrical-vermiform, sinuous, capitate, these latter 9–10 µm broad at apex] appear intermixed. In most areas the pileocystidia grow from irregular (17–68 × 8–15 µm) or somewhat subisodiametric (15–20 × 15–18 µm) elements arranged in chains of up to two cells. The pileocystidia in *L. fumosoides* (type specimen) are long and slender and somewhat resemble a trichodermis and thus differing from those seen in the other collections of *L. fumosibrunneus*.

We therefore agree with Smith & Hesler (1962) that *L. fumosibrunneus* represents a distinct taxon based on the pileipellis structure, consistent presence and shape of cheilocystidia, the size, shape, and ornamentation of basidiospores, color changes and taste of basidiomes, and the shape and disposition of lamellae. It should be noted that the hot taste seems to be directly associated with latex in that basidiomes lacking latex tasted mild or at least less acrid that the basidiomes with latex.

It is interesting to note that after Peck (1885) treated *L. fumosus* as *L. fuliginosus* (Fr.) Fr., Saccardo (1887) reduced Peck's taxon to a variety, as "*L. fuliginosus* var. *fumosus* Peck". The European *Lactarius fuliginosus* (Fr.) Fr. and *L. azonites* (Bull.) Fr. (another species within this group), which share a more or less similar habit with *L. fumosibrunneus*, can be distinguished by moderately distant gills, mild or bitter to slightly acrid latex (Heilmann-Clausen et al. 1998, Basso 1999), bigger basidiospores [X = 8.0–8.6 × 7.4–7.8 µm (in *L. azonites*) or X = 8.1–8.4 × 7.1–7.6 µm (in *L. fuliginosus* with a wider Q range, 1.09–1.15; Heilmann-Clausen et al. 1998], and a pileipellis with somewhat longer terminal elements that give a trichodermoid aspect to the suprapellis (20–40 × 3–5 µm in *L. azonites* and 20–45 × 5–8 µm in *L. fuliginosus*; Heilmann-Clausen et al. 1998).

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